Are We Appropriately Treating Infrapopliteal Arterial Disease? The Need for Precision Imaging With Intravascular Ultrasound

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Abstract: We present a case of severe stenosis of the tibioperoneal trunk treated under angiographic and intravascular ultrasound (IVUS) guidance. In this case, angiography significantly under-estimated the true vessel size by 33.6% and failed to identify the presence of dissections when compared to IVUS. The lack of precision imaging may be one mechanism that explains the failure of some drug-coated balloons in below-the-knee interventions and why ~20% of drug-eluting stents fail to maintain patency at 1-year follow-up. Furthermore, under-estimating the number and severity of dissections by angiography may have significant implications on the outcome of an intervention.

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Key words: angiography, below the knee, dissection, IVUS, quantitative angiography, tibial artery, under-sizing, iDissection

Angiography has been shown to be a suboptimal imaging modality to identify intraluminal arterial pathology. Angiography under-estimates the presence of thrombus and calcium, vessel size, stent expansion, stent apposition, presence and severity of dissections, and true extent of disease.[1-8] Multiple treatment modalities have been proposed to treat infrapopliteal disease. Angioplasty (PTA) carries overall poor results with reduced patency at 1 year.[9] Also, patency is not improved over PTA with the use of bare-metal stenting (BMS)[10] or the In-Pact or Bioluxe-PII drug-coated balloon (DCB).[11,12] Drug-eluting stent (DES) implantation showed significantly better patency than PTA and/or BMS at 1-year follow-up. However, despite very short lesions, these studies showed ~20% restenosis rate with DES.[13-15]

There are many factors that could potentially affect restenosis in infrapopliteal disease, including recoil, negative remodeling, and smooth muscle cell proliferation. Vessel wall stretch and to a lesser extent plaque compression are the main mechanisms to achieve acute lumen gain.[16] Vessel stretching quite often leads to dissection. In the case of drug-eluting devices, adequate drug delivery to prevent smooth muscle cell proliferation is a key to improve patency. The ability of the drug to reach the vessel wall is a critical first step. From there, the drug has to penetrate the vessel wall at a sufficient concentration and depth to have a critical therapeutic concentration. Therefore, adequate sizing of the balloon or the stent to the vessel wall becomes an additional critical step in endovascular procedures to ensure proper drug uptake.

CASE PRESENTATION

We present a case of a tibioperoneal trunk (TPT) stenosis treated as part of the currently enrolling iDissection below-the-knee (BTK) feasibility study. This prospective study is evaluating the pattern of dissections in infrapopliteal disease based on the iDissection classification[17] with IVUS, and determining the adequacy of angiography in achieving optimal balloon and stent sizing. Our patient presented with limiting claudication and was found to have multivessel tibial disease (90% right TPT and 90% proximal right anterior tibialis focal disease). We elected to treat the right TPT, as this was felt to be sufficient to take care of his symptoms. As part of the iDissection BTK protocol, angiography was performed to identify the worst lesion severity. IVUS was then performed and reference vessel diameter was measured from the external elastic lamina (EEL) to EEL and internal elastic lamina (IEL) to IEL. Using a 5.0 x 20 mm Emerge balloon (Boston Scientific), the lesion was treated with up to 12 atm of pressure for 180 seconds. IVUS was then repeated. The intention was to do primary stenting on this vessel to reduce the chance of restenosis. Based on sizes obtained from the IVUS, a 4.0 x 18 mm Onyx stent (the largest coronary stent we had on the shelf) (Medtronic) was placed and postdilated with a 5 x 20 mm Emerge balloon up to 14 atm.

Images were adjudicated by the quantitative vascular lab (QVL) at the Midwest Cardiovascular Research Foundation using Echoplaque software (INDEC Systems) for IVUS analysis and CAAS software (Pie Medical Imaging) for angiographic analysis. The presence of dissection was then additionally adjudicated independently by the core lab using the NHLBI classification for angiographically visible dissections[18] and the iDissection classification[17] for IVUS-visible dissections.

Figure 1 illustrates the quantitative angiographic reading of the reference vessel diameter, which measured at 3.32 mm. Figure 2 illustrates the IVUS measurements and presence of dissections. The vessel diameter from EEL to EEL measured at a mean of 6.4 mm and from IEL to IEL at 5 mm. When compared to the IEL to IEL diameters, angiography under-estimated the lumen size by 33.6%.

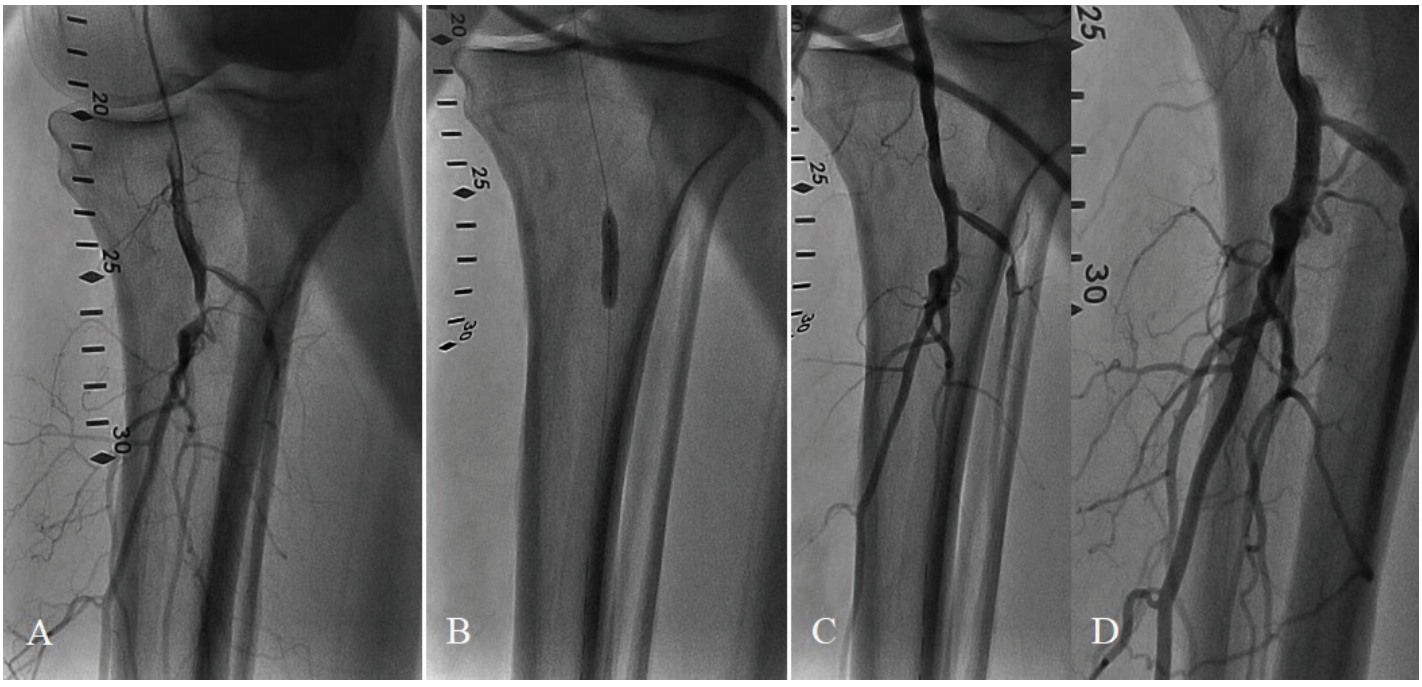

Figure 1. **(A)** Baseline lesion. **(B)** Angioplasty with balloon inflated. **(C)** Post angioplasty. **(D)** Post stenting.

If the PTA balloon is sized based on EEL to EEL diameter for an optimal vessel stretching, then it would have been under-sized by 48.1%. Furthermore, the angiogram did not demonstrate any dissection, whereas two type A1 dissections were noted using IVUS (intimal tear and <180° in circumference). After stenting, the lumen diameter by IVUS was 5 mm (Figure 2) and full stent expansion and apposition were noted. Patient did well with no complications.

DISCUSSION

In this case, we illustrate the inadequacy of angiography for sizing infrapopliteal vessels and for identifying dissections. The large magnitude of the discrepancy in vessel diameter and in identifying dissections by angiography is well illustrated in this case report. This may be one mechanism that explains the failure of some BTK interventions to reduce late lumen loss in well-designed randomized trials.[11,12] This may also explain why ~20% of DES cases fail to maintain patency at 1-year follow up. Although other mechanisms such as severe calcification and medial calcinosis in the tibials may be responsible for this lack of effectiveness, we believe that precision imaging is critical in accurately sizing the vessel, properly identifying dissections, and directing the choice of treatment. ■

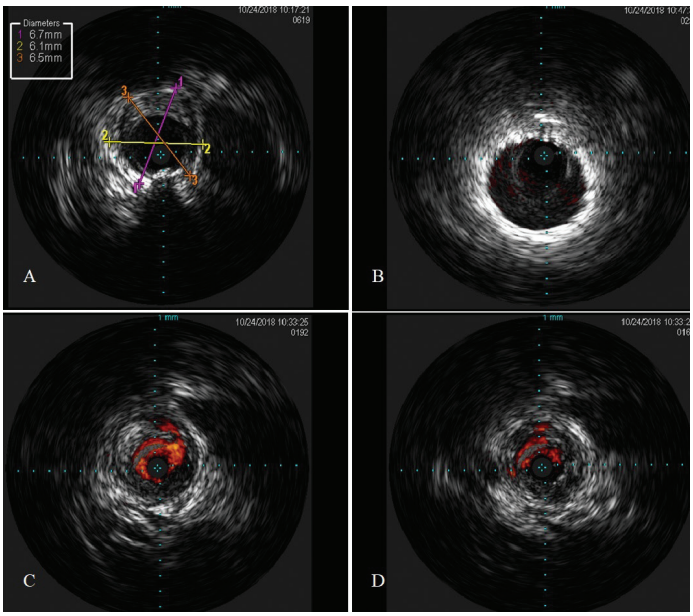

Figure 2. **(A)** Baseline intravascular ultrasound image (measurements indicate external elastic lamina to external elastic lamina). **(B)** Post stenting. **(C)** First dissection (intimal). **(D)** Second dissection (intimal).

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The authors report that patient consent was provided for publication of the images used herein.

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INTENDED USE:
The Tack Endovascular System (4F, 1.5-4.5mm) is intended for use in mid/distal popliteal, tibial and peroneal arteries, ranging in diameter from 1.5 mm to 4.5 mm, for the repair of post percutaneous transluminal balloon angioplasty (PTA) dissection(s).

CONTRAINDICATIONS FOR USE:
The Tack Endovascular System is contraindicated for the following: 1. Patients with residual stenosis in the treated segment equal to or greater than 30% after PTA. 2. Tortuous vascular anatomy significant enough to prevent safe introduction and passage of the device. 3. Patients with a known hypersensitivity to nickel-titanium alloy (Nitinol). 4. Patients unable to receive standard medication used for interventional procedures such as anticoagulants, contrast agents and antiplatelet therapy.

Prior to using the Tack Endovascular System, please review the Instructions for Use for a complete listing of indications, contraindications, warnings, precautions, potential adverse events and directions for use.

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